USFWS/USGS Structured Decision Making Workshops (ALC3159)

Atlantic salmon conservation hatchery management within the Gulf of Maine Distinct Population Segment

Authors: Peter Lamothe[1], John Sweka[2], John Kocik[3], Joseph Zydlewski[4], Meredith Bartron[2], Mike Millard[2], Dan McCaw[5], Oliver Cox[6], Dan Kircheis[3], Laury Zicari[7], Dwayne Shaw[8]

Coaches: Conor McGowan[9], Jonathan Cummings[10], Sarah Jacobi[11]

Decision Problem

The U.S. Fish & Wildlife Service (USFWS) Maine Fisheries Program Complex includes two federal conservation hatcheries, Craig Brook National Fish Hatchery (CBNFH) and Green Lake National Fish Hatchery (GLNFH). These two hatcheries serve as refugia for seven river-specific, genetically unique broodstock populations of Atlantic salmon (*Salmo salar*). The staff at CBNFH maintains captive broodstock lines for: the Dennys, Machias, East Machias, Pleasant, Narraguagus, and Sheepscot rivers (Fay et al. 2006, USFWS and NOAA 2014) (Figure 1). The broodstocks for these rivers are maintained by planting or stocking 100,000's eggs or salmon fry into the river of origin in the late winter or spring of the year. In the fall of the year, 200-300 salmon parr are collected for each river and returned to CBNFH to be raised to adults and spawned in the hatchery (Bartron et al. 2006). The staff at CBNFH also annually spawns sea-run adult salmon captured in the Penobscot River. Approximately 2.5 million eggs are fertilized annually from these sea-run adults and 1.5 million of these fertilized eggs are raised at CBNFH and released in the spring of the year as salmon fry back into the Penobscot River. The remaining 1.0 million fertilized eggs are transferred to GLNFH and raised to produce approximately 550,000 salmon smolts and 300,000 parr to be released back into the Penobscot River. The staff at GLNFH also maintains a domestic line of broodstock for the Penobscot River that is in place ultimately as a "backup" to the sea-run fish should either: adult returns to the Penobscot River be below established targets (650 adults), poor fertilization rates of spawned eggs, or high mortality of fertilized eggs due a disease outbreak, occur within a given year. In most years, when the "back-up" isn't needed for the Penobscot River the eggs from the domestic line are stocked into the Kennebec River watershed. Under this management approach approximately 65% of operating budgets for the two hatcheries is dedicated to propagation of Atlantic salmon for the Penobscot River.

[1] USFWS Fisheries Program, East Orland, ME, peter_lamothe@fws.gov
[2] USFWS Fisheries Program, Lamar, PA
[3] NOAA Northeast Fisheries Science Center – Maine Field Center, Orono, ME
[4] USGS Maine Cooperative Fish and Wildlife Research Unit, Orono, ME
[5] Penobscot Indian Nation, Indian Island, ME
[6] Maine Department of Marine Resources, Hallowell, ME
[7] USFWS Ecological Services Office, Orono, ME
[8] Downeast Salmon Federation, Columbia Falls, ME
[9] USGS Alabama Cooperative Fish and Wildlife Research Unit, Auburn, AL
[10] Vermont Cooperative Fish and Wildlife Research Unit, Burlington, VT
[11] Chicago Botanic Garden, Glencoe, IL

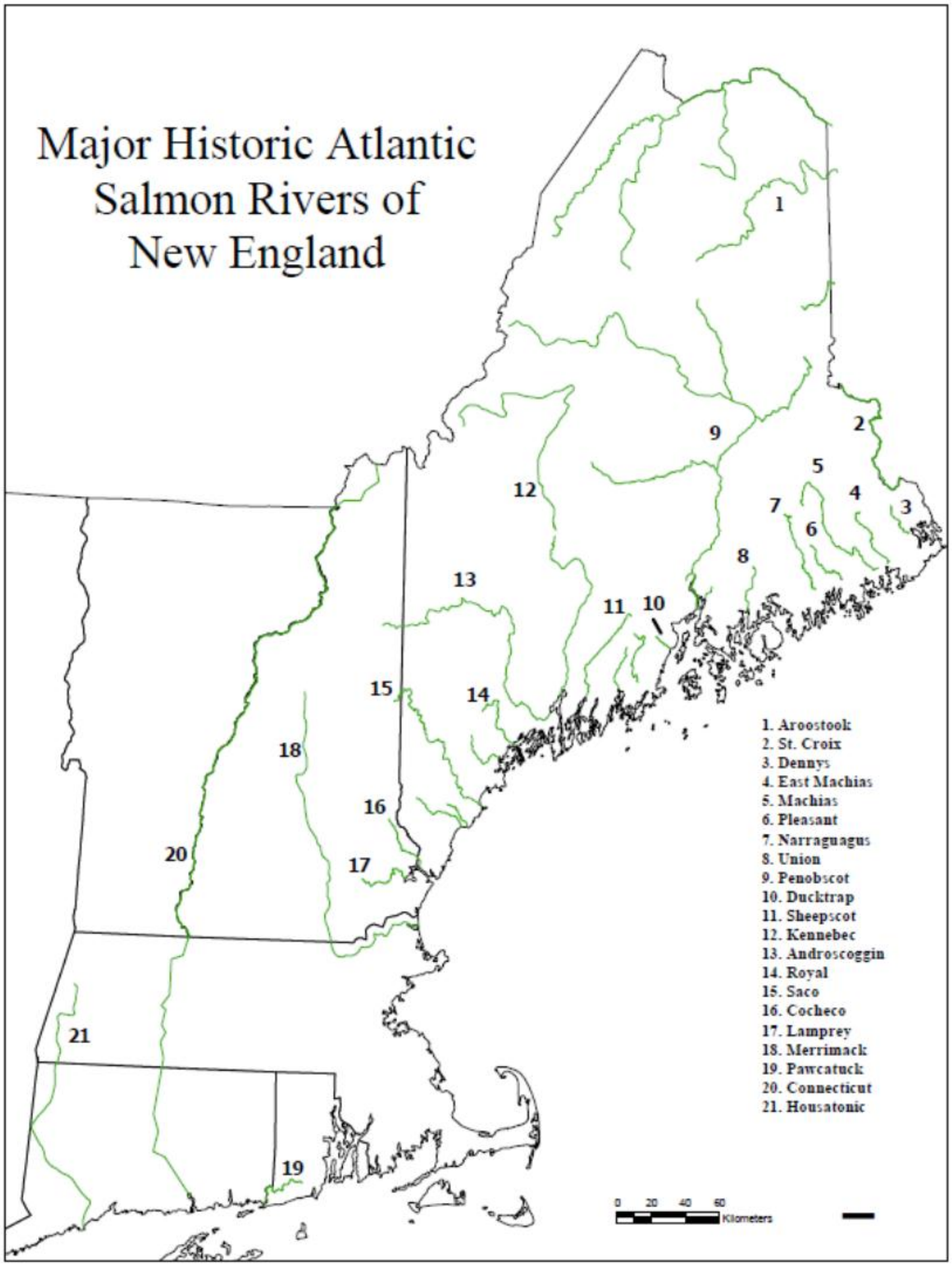

Figure 1. Freshwater range map for Atlantic salmon in the United States (Fay et al. 2006). The USFWS maintain river specific hatchery broodstock for the Dennys (3), East Machias (4), Machias (5), Pleasant (6), Narraguagus (7), and Penobscot (9) rivers. Penobscot strain salmon are also currently being stocked into the Sandy River, a tributary of the Kennebec River (12).

These broodstock populations along with wild salmon within the Gulf of Maine Distinct Population Segment (GOM DPS) are listed as endangered under the Endangered Species Act (Figure 2). Without these broodstock populations, Atlantic salmon in Maine would likely become effectively extinct.

Recent budget reductions at the Maine Fisheries Program Complex have required staff to take a strategic look at the program, with the goal of identifying priorities. **This case study considers the management of seven river specific brood stocks from the perspective of how should the USFWS, in partnership with NOAA, MDMR, PIN, USGS and NGO's use Atlantic salmon brood stock and the hatchery system to minimize risk of Atlantic salmon decline in terms of abundance, distribution, and genetic diversity within the three Salmon Habitat Recovery Units given current and future budget constraints?** In addressing this problem it is particularly imperative that the decision process be transparent and recognizes the importance and values of our partners.

Background

Atlantic salmon populations in the United States have been grouped into the Long Island Sound, Central New England, and Gulf of Maine population segments (Fay et. al 2006) (Figure 2). Under the Endangered Species Act (ESA), a population segment of a vertebrate species is treated as a species for listing and recovery purposes if it meets the qualifying criteria defined by the joint Distinct Population Segment (DPS) policy of 1996 (61 FR 4722).

In the Long Island Sound and Central New England population segments, all native Atlantic salmon populations have been extirpated, although salmon are still present because of reintroduction programs for the Connecticut River and Merrimack River. Only the Gulf of Maine still contains native wild salmon populations, all of which are at extremely low population size, leading to the designation of this population segment as a DPS. The GOM DPS of Atlantic salmon DPS was first listed by the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (collectively referred to as the Services) as endangered under the ESA in 2000 (65 FR 69469). The 2000 GOM DPS included all naturally reproducing remnant populations of Atlantic salmon from the Kennebec River downstream of the former Edwards Dam site, northward to the mouth of the St. Croix River. At the time of the 2000 listing, however, there were uncertainties associated with biological and genetic relationships of Atlantic salmon inhabiting the Androscoggin River, Kennebec River, and Penobscot River to wild Atlantic salmon populations.

A subsequent status review by Fay et al. (2006) recommended that the GOM DPS be expanded to include all naturally reproducing anadromous Atlantic salmon having a freshwater range in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, including all associated conservation hatchery populations used to supplement these natural populations. The marine range, which remained unchanged, extends from the GOM throughout the Northwest Atlantic Ocean to the coast of Greenland. The Services jointly listed this expanded GOM DPS as endangered on June 19, 2009 (74 FR 29344), based largely on the information summarized by Fay et al. (2006). The expansion of the GOM DPS and limitations to capacity at the USFWS conservation hatcheries left the Androscoggin, Kennebec and other smaller watersheds within the GOM DPS without river-specific broodstocks for recovery efforts.

Figure 2. Freshwater range of Atlantic salmon in the United States: Watersheds that currently or historically supported Atlantic salmon populations in the United States. Rivers are grouped into three population segments (Fay et al. 2006).

Decision Structure

Objectives

The group identified three fundamental objectives and their associated means objectives to better manage the USFWS conservation hatcheries in Maine under the current and potentially future budget challenges. The fundamental objective of using the USFWS conservation hatcheries primarily as a tool for preventing extinction represents a significant shift in approach from previously stated strategies of using hatchery stock to maximize the abundance of adult Atlantic salmon spawners within the rivers of the GOM DPS (NMFS et al. 2011).

Fundamental objectives:

A) **Minimize probability of extinction of GOM DPS Atlantic salmon:** The group decided that the primary role of the USFWS Atlantic salmon conservation hatcheries in Maine was the prevention of extinction of Atlantic salmon within the GOM DPS. Seven river specific broodstocks of Atlantic salmon were established in the early 1990's by the USFWS and its partners. The maintenance of these brood populations within the hatcheries, using stocking into freshwater and marine environments for selective pressure, allows these seven populations to persist while efforts continue to identify, remove and abate imminent threats to this endangered species.

B) **Maximize probability of producing self-sustaining "wild" populations:** The group decided that while using hatchery fish to prevent extinction, it was imperative that hatchery fish were managed in a manner that minimized interactions with "wild" or naturally reared salmon within a given river. This decision would limit stocking of hatchery salmon in locations where salmon spawning is observed by management biologists.

C) **Maximize probability of meeting annual budget targets and constraints:** The group chose to recognize the importance of operating the USFWS conservation hatcheries within current and future budget constraints.

Means Objectives:

The group also identified 13 means objectives. The list of means objectives represents the suite of management objectives associated with recovery efforts of Atlantic salmon in the GOM DPS.

A) Maximize # of habitat units occupied by Atlantic salmon that are suitable and accessible
B) Maximize occurrence of Atlantic salmon in number of river basins
C) Maintain genetically and behaviorally distinct population(s).
D) Maximize genetic isolation of river specific Atlantic salmon stocks
E) Maximize genetically fit populations of Atlantic salmon
F) Minimize loss of hatchery family groups
G) Maximize adult Atlantic salmon returns to GOM DPS rivers

H) Maximize total viable hatchery product
I) Maximize effective population size
J) Maximize natural spawning of Atlantic salmon (successful)
K) Minimize interactions between hatchery and naturally reared Atlantic salmon (manage in a way that maximizes probability of survival for both components of the overall population)
L) Minimize domestication effects of Atlantic salmon (time in hatchery; # of females, etc...)
M) Maximize stage specific survival of Atlantic salmon (hatchery and naturally reared)

Alternative Actions

Seven alternatives were developed by the group to test the effectiveness of different Atlantic salmon stocking strategies in meeting the stated fundamental objectives. The alternatives are summarized as:

1. **The status quo of hatchery production:** This alternative would leave production at the two Atlantic salmon conservation hatcheries in Maine unchanged (Table 1).

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: The development of the seven river-specific broodstocks have effectively minimized the probability of extinction of GOM DPS Atlantic salmon over the last 20 years.

   Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated with the status quo hatchery production have not been successful in producing self-sustainable "wild" salmon populations in the GOM DPS. Additional work to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and other limiting factors is likely required before we are able to produce self-sustainable "wild" Atlantic salmon populations in the GOM DPS.

   Maximize probability of meeting annual budget targets and constraints: The cost of producing the 'status quo" would exceed our hatchery operation budgets under the new lower budget projections.

Table 1. Current hatchery production numbers, including life-stage at stocking for each of the river-specific broodstocks maintained at the USFWS Atlantic salmon conservation hatcheries.

Broodstock (River of Origin)	Eggs	Fry	Parr	Smolts	Adults
Dennys					257
East Machias	53,200	88,000			52
Machias		231,000	1,400		81
Narraguagus		389,000		59,100	
Pleasant	53,200	40,000		60,000	56
Penobscot (Sea-runs)	352,389	1,100,000	300,000	550,000	
Penobscot (Domestic)	860,000				
Sheepscot	70,000	50,000	15,700		35

2. **Increase salmon parr production for the Dennys, East Machias, Machias, Narraguagus, and Pleasant rivers and no salmon smolts in the Penobscot River:** This alternative would shift hatchery production at Green Lake NFH by eliminating salmon smolt production for the Penobscot River which annually is approximately 550,000 smolts, with salmon parr for the rivers in the Downeast SHRU.

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: The current approach to managing the Penobscot River broodstock is dependent on adult returns from salmon smolt stocking. Without a shift in approach of managing this broodstock, the Penobscot River population would be of increased risk of extirpation. An alternative would be to use the domestic broodstock for the Penobscot River to meet production targets for salmon fry and smolts. This shift would end the availability of eggs for stocking efforts in the Kennebec River watershed.

   Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated with increased parr production have not been successful in producing self-sustainable "wild" salmon populations in the GOM DPS.

   Maximize probability of meeting annual budget targets and constraints: The shift in hatchery production from smolts for the Penobscot River to salmon parr for five other rivers would likely not allow the hatcheries to operate under the reduced budget amounts. Other constraints, such as hatchery space and nutrient discharge limits at CBNFH and GLNFH also limit the feasibility of this alternative.

3. **20% reduction of status quo hatchery production across the broodstock portfolio:** This alternative would reduce hatchery production by 20% across the board at both Craig Brook and Green Lake NFH's. All broodstock populations would be reduced equally.

Relationship to Fundamental Objectives:

Minimize probability of extinction: An across the board cut to broodstock numbers would potentially result in a significant drop in genetic diversity and effective population size for each of the populations. The low rate of salmon survival currently occurring within both the freshwater and marine habitats would put these populations at risk to loss of genetic diversity and eventual local extirpation.

Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated with the status quo hatchery production have not been successful in producing self-sustainable "wild" salmon populations. A reduction in hatchery production of 20% would not likely improve the probability of moving the population towards self-sustainability. Additional work to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and other limiting factors is likely required before we are able to produce self-sustainable "wild" populations.

Maximize probability of meeting annual budget targets and constraints: A 20% reduction in hatchery production would likely allow for the reduced budget targets to be met by the hatcheries.

4. **Reduce Penobscot River salmon smolt production; increase production in Penobscot River salmon parr:** This alternative would reduce the number Atlantic salmon smolts and increase the number of salmon parr produced at GLNFH. Salmon parr at GLNFH are a by-product of smolt production.

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: The shift in hatchery production for the Penobscot River from smolts to parr would likely lead to reduced numbers of returning adult salmon to the river. This could, depending on survival rates, to an increased risk to the Penobscot River broodstock population. An alternative would be to use the domestic broodstock for the Penobscot River to meet production targets for salmon fry and parr. This shift would end the availability of eggs for stocking efforts in the Kennebec River watershed.

   Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated the stocking of salmon parr have not been successful in producing self-sustainable "wild" salmon populations in the GOM DPS. Additional efforts to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and others is likely required before we are able to produce self-sustainable "wild" populations in the GOM DPS.

Maximize probability of meeting annual budget targets and constraints: A shift from salmon smolt to parr production at GLNFH would likely allow for reduced budget targets to be met by the hatcheries.

5. **Increase smolt and parr production in Downeast Rivers; reduce smolts for Penobscot River:** This alternative would focus salmon and smolt production in the Downeast rivers. The increase in smolt production for the Downeast Rivers would be offset by a reduction in smolt production for the Penobscot River.

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: The shift in hatchery production to smolts for the Downeast Rivers and reduced smolts for the Penobscot River would likely lead to reduced numbers of returning adult salmon to the Penobscot River. This could, depending on survival rates, to an increased risk to the Penobscot River broodstock population. An alternative would be to use the domestic broodstock for the Penobscot River to meet hatchery production targets for salmon fry and smolts. This shift would end the availability of eggs for stocking efforts in the Kennebec River watershed.

   Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated with hatchery production have not been successful in producing self-sustainable "wild" salmon populations. Additional work to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and other limiting factors is likely required before we are able to produce self-sustainable "wild" populations in the GOM DPS.

   Maximize probability of meeting annual budget targets and constraints: This alternative would not allow the hatcheries to operate within their budgetary constraints.

6. **Stock all salmon in rivers as eggs:** This alternative would replace salmon fry, parr, and smolt production in all seven rivers with salmon egg planting in the late winter of the year.

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: This alternative would replace fry, parr, and smolt production and stocking with salmon egg planting efforts in the late winter of the year. This approach would likely be effective for each of the rivers accept the Penobscot River. The broodstock management approach for the Penobscot River is dependent on adult returns from smolt stocking. An alternative would be to use the domestic broodstock for the Penobscot River as the "back-up" it was developed to be. This shift would end the availability of eggs for stocking efforts in the Kennebec River watershed.

   Maximize probability of producing self-sustainable "wild" populations: To date, the stocking strategies associated with hatchery production have not been successful in producing self-sustainable "wild" salmon populations. Additional work to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and other limiting factors is likely required before we are able to produce self-sustainable “wild” populations in the GOM DPS.

Maximize probability of meeting annual budget targets and constraints: A shift to all egg planting as a stocking strategy would likely allow for reduced budget targets to be met by the hatcheries.

7. **Add post spawn salmon (kelts) to the status quo:** Under this alternative, in addition to the status quo hatchery production, a portion of adult salmon spawned in the fall of the year (50-100 individuals) would remain at the hatchery, rather than being returned to the river of origin, to be fed and rehabilitated for future egg production.

   Relationship to Fundamental Objectives:

   Minimize probability of extinction: The development of the seven river-specific broodstocks have effectively minimized the probability of extinction of GOM DPS Atlantic salmon over the last 20 years. This alternative would require the hatcheries to hold post spawn adult salmon (50-100 individuals), rejuvenate these fish, and spawn them again in the future. This management approach would replace the current approach of releasing all adults after spawning in the hatchery into the river of origin

   Maximize probability of producing self-sustainable “wild” populations: This alternative has the potential to increase the number of salmon available for stocking efforts in the future. To date, the stocking strategies associated with the status quo hatchery production have not been successful in producing self-sustainable “wild” salmon populations. Additional work to address limiting factors such as: passage at hydro-electric dams, marine and freshwater habitat suitability, passage at stream-road crossings and other limiting factors is likely required before we are able to produce self-sustainable “wild” populations.

   Maximize probability of meeting annual budget targets and constraints: This alternative would not allow the hatcheries to operate within their budgetary constraints.

Predictive Model

Consequences and Trade-offs:

The described alternatives were tested to determine the impact to hatchery operating budgets and adult salmon returning to rivers within the GOM DPS. Two modeling exercises were carried out by the group.

1) The question of risk to the loss of families under various stocking strategies was assessed by using the estimated survival of individuals across all life history stages and the probabilities of at least one individual from a family surviving to adulthood (assumed to spawn in either the natural environment or taken to the hatchery as sea run broodstock). It was clear that all methods except

maintaining captive brood (i.e. pedigree lines) had some level of risk of family loss, though smolt stocking had the highest probability of retention of family groups.

2) A second model applied "value" to hatchery strategies based upon the a) total relative cost of numbers and life stages produced, b) the expected number of adult returns produced given estimates of fecundity and survival, and c) a relative weighting of the origin of returns (e.g. naturally reared returns had a higher value than those from smolt stockings).Though this model's parameters were intended to be best estimates, the model's utility was in relative comparisons of different management approaches.

The following graph shows results from the second modeling exercise (Figure 3). Note that the resulting value is not equal to the number of returning adult salmon but is a value which is a function of both the number of returns weighted by the origin of the returns (i.e. naturally reared, salmon parr, or smolt stocked) produced for the purpose of comparison among the alternatives:

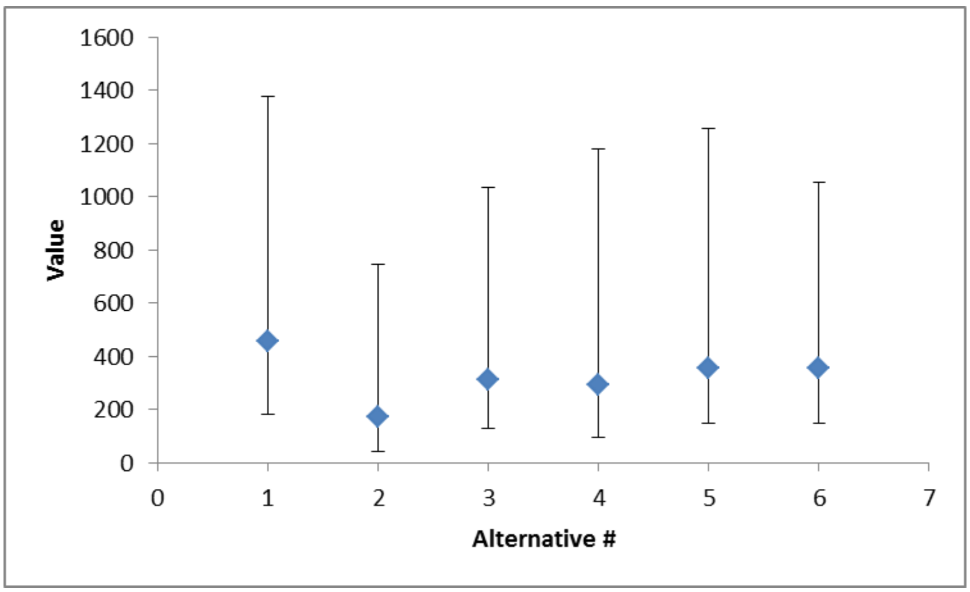

Figure 3. Model results based on associated cost, the expected number of adult returns and a relative weighting of the origin of returns (hatchery vs. naturally reared). The model assumes all alternatives are similar in terms of loss of family groups (genetic variability).

Decision Analysis

It was first noted that all alternatives have a high degree of variability in expected output values. While the status quo alternative (Alternative 1) ranked highest, the variability within all alternatives renders conclusions from this exercise uncertain. Alternative 7 resulted in no value because the status quo plus the rearing, rejuvenation of kelts and the rearing of the juveniles produced from the kelt eggs exceeded the budget constraints established for the model. These results imply that variation in freshwater and marine survival has a much greater effect on expected adult returns than the differences among alternatives in terms of numbers and life stages stocked.

Uncertainty

In this decision problem, there are several areas of uncertainty that the group had to manage throughout the process. First, was the exact amount of the anticipated reduction to operation budgets for the hatcheries. Entering into the workshop we were anticipating a reduction of 20%. That target for reduction was actually increased to approximately 35%. Salmon survival rates in both the freshwater and marine environments represent a significant source of uncertainty and come from both predictable and stochastic events within these habitats. The ability of wild salmon populations to maintain a level of self–sustainability is also a significant source of uncertainty.

Discussion

Value of decision structuring

The decision making structure was very valuable in that it focused our group in identifying the appropriate problem statement and fundamental objectives for the Maine Atlantic salmon conservation hatcheries (Hammond et al. 1999). The primary fundamental objective identified by the group for the conservation hatcheries was different from previously stated fundament objectives or strategies. This difference led to some challenges in working through the decision structuring process especially the identified alternative actions. Using stocking strategies exclusively as alternative actions limited the identification of potential actions to minimize the probability of extinction for Atlantic salmon in the GOM DPS.

Further development required

This decision making structure was valuable and helped the group look at the role of the Atlantic salmon conservation hatcheries in new ways. The decision structure for this problem would benefit from expanding the list of potential alternative actions that include actions other than strategies (salmon life stage and numbers) for stocking the rivers within the GOM DPS. The group identified the development of pedigree lines within the hatcheries as an important tool for minimizing the loss of genetic diversity and the probability of extinction within each of the river-specific broodstocks. This potential alternative was not modeled to predict its effects on the identified fundamental objectives of maximizing the probability of developing self-sustainable “wild” salmon populations and meeting our annual budget targets for the hatcheries. Additional alternatives linked to recovery actions such as habitat enhancement or fish passage projects could be incorporated into the model, as well.

Prototyping process

The mid-week deadline for navigating through the PrOACT steps served as a helpful motivating factor and training process to understanding the decision making structure. For example, at mid-week our group’s fundamental objectives included the reestablishment of a recreational fishery for Atlantic salmon in the GOM DPS. As the week progressed this fundamental objective was removed by the group because it was recognized that meeting this objective was outside the control of the conservation hatcheries. Without working through the PrOACT steps twice there would have been limited opportunity to revisit each of the steps, like identification of objectives, potentially limiting the group's ability to clearly understand the problem, hone in on the true fundamental objectives and enhance our ability to make the best decision possible.

Recommendations and Actions

The group left the workshop with three themes to the final decision making process. The final decision should allow for: 1) the continuation of the seven river specific Atlantic salmon broodstocks maintained by the conservation hatcheries; 2) the need for increased balance in terms of resources committed to individual broodstocks; and 3) ideally the short term decision motivated by reductions in operating budgets should position the conservation hatcheries to meet the fundamental objective of preventing extinction into the future. The next steps identified by the group at the end of the workshop included continued communication as the decision was finalized by the principal investigator. The group met multiple times following the workshop to further develop the models used in the decision making process and to update the group on guidance being received related to budget targets. Ultimately, operating budgets for the conservation hatcheries were reduced by a greater amount (approximately 35%) than originally anticipated. Largely due to the SDM workshop and the decision structuring process a framework was in place to manage this change.

The final decision in the process was made in early January 2014. Budget guidance at that time was that operating budgets for the Maine Fisheries Complex needed to be reduced by 35%. Since none of the alternative approaches created during the workshop met all three of the groups identified fundamental objectives for the salmon conservation hatcheries, a combination of alternatives was developed by the decision maker. Due to its importance in maintaining the seven river-specific broodstock populations, the operating budget for CBNFH was reduced by approximately 5%. The operating budget for GLNFH was reduced by approximately 45%. Additional cuts were made to the Maine Fisheries Resource Office and the Complex management office to meet our obligations. Managing the cuts in this manner achieved the fundamental objectives of preventing extinction and meeting the hatcheries budget constraints and obligations. The fundamental objective of maximizing the probability of producing self-sustaining "wild" populations as this time is largely linked to identifying and removing known limiting factors in the freshwater and marine environments and beyond the conservation hatcheries area of direct influence.

Table 2. Relationship of developed alternatives to fundamental objectives for the decision making process.

Alternative	Prevents Extinction	Produces Self-Sustainable Populations	Meets Budget Constraints
1	Yes	No	No
2	No*	No	No
3	No	No	Yes
4	No*	No	Yes
5	No*	No	No
6	No*	No	Yes
7	Yes	No	No

***Alternative would likely lead to end of stocking efforts in the Kennebec River watershed and increased uncertainty of maintaining Atlantic salmon broodstock for the Penobscot River.

Specifically, salmon smolt production was reduced by approximately 50% to 275,000 fish that will be stocked into the Penobscot River in 2015. It is our hope that the survival of these fish will be high enough to meet our broodstock targets of 650 adults for the river in 2017. If brood stock targets are not met, then eggs from the domestic line for the Penobscot will have to be used to meet salmon production targets. The hope is that this approach will still allow for some salmon egg planting to continue within the Kennebec River watershed (Sandy River).

Table 3. Number and life stage of salmon anticipated to be available for stocking into the river of origin within the GOM DPS. Final numbers and life stage are developed in partnership with Maine DMR.

Broodstock (River of Origin)	Eggs	Fry	Parr	Smolts	Adults*
Dennys		127,000			50
East Machias			205,000		130
Machias		139,000			200
Narraguagus		253,000			145
Pleasant		250,000			130
Penobscot (Sea-runs)		872,000		275,000	N/A
Penobscot (Domestic)	620,000				1,200
Sheepscot	223,000		18,000		120

*Post spawn

Literature Cited

Bartron, M., D. Buckley, T. King, T. King, M. Kinnison, G. Mackey, T. Sheehan, K. Beland, and J. Marancik. 2006. Captive Broodstock Management Plan for Atlantic salmon at Craig Brook National Fish Hatchery. Prepared for the Atlantic salmon Technical Advisory Committee.

Fay, C.M., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan and J. Trial. 2006. Status review for anadromous Atlantic salmon (*Salmo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish & Wildlife Service. 294 pp.

USFWS and NOAA. 2014 Draft Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*). First Revision 2014. U.S. Fish and Wildlife Service, Hadley, Massachusetts.

National Marine Fisheries Service, Maine Department of Marine Resources, U.S. Fish & wildlife Service, and the Penobscot Indian Nation. 2011. Atlantic Salmon Recovery Framework. National Marine Fisheries Service, Silver Springs, Maryland.

Hammond, J.S., R.L. Keeney, and H. Raiffa. 1999. Smart Choices: A Practical Guide to Making Better Life Decisions. Broadway Books, New York, NY.